(12) UK Patent Application (19) GB (11) 2 081 845 A

(21) Application No 8116443
(22) Date of filing 29 May 1981
(30) Priority data
(31) 8017620
(32) 29 May 1980
(33) United Kingdom (GB)
(43) Application published 24 Feb 1982
(51) INT CL[3] F16K 31/12
(52) Domestic classification F2V T17 T19 T25 T28 T4A
(56) Documents cited
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(58) Field of search F2V

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(54) Control valve

(57) A control valve has an inlet (1) and an outlet (2) for fluid, the passage of which is controlled by a movable valve member (4) cooperating with a valve seat (3). Detecting means constituted by a bellows (5) and a remote air sensor (9) to detect temperature changes at two separate locations. The detecting means cooperate with the valve member (4) such that temperature changes over at least part of the operating temperature range of the apparatus at both locations cause the valve member (4) to move relative to the valve seat (3).

Fig.2.

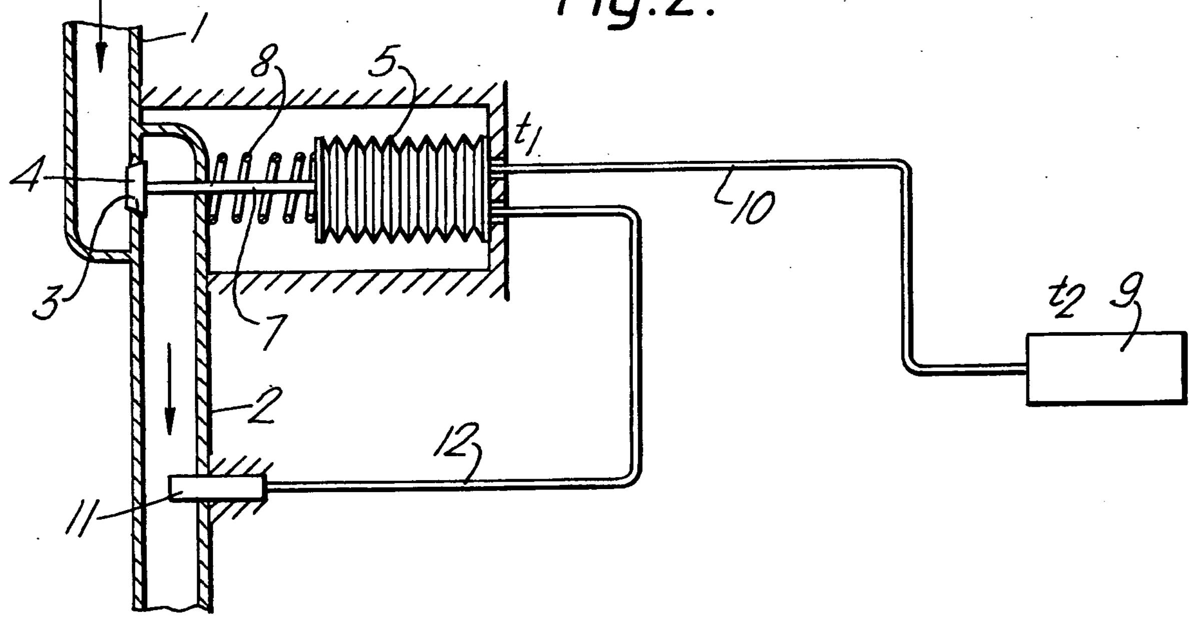

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Fig. 1.

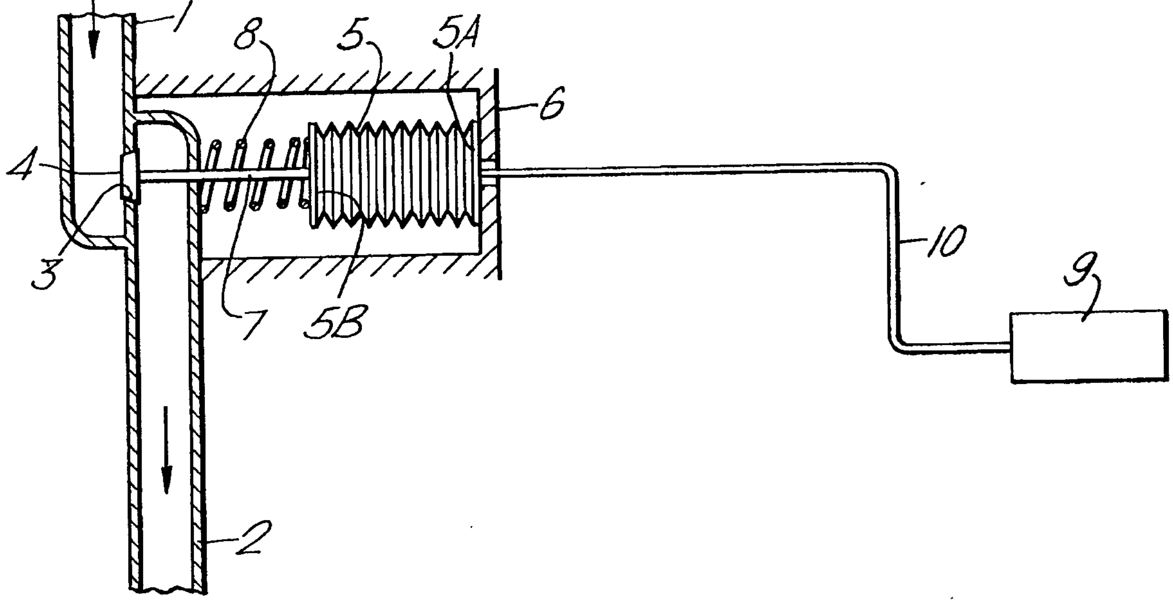


Fig. 2.

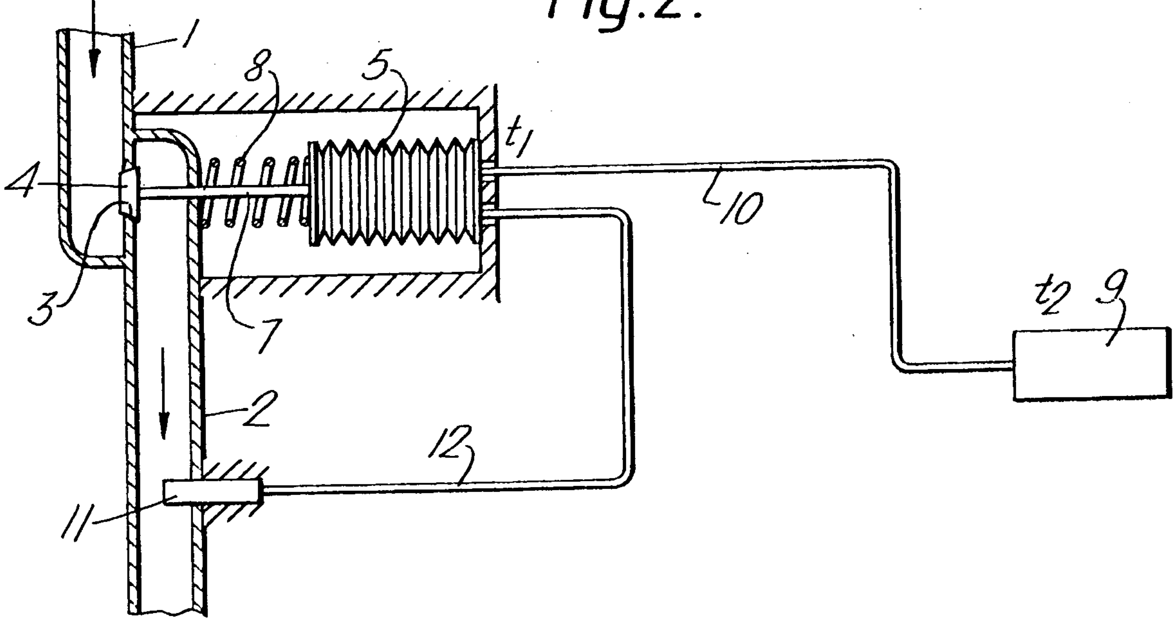


Fig. 3.

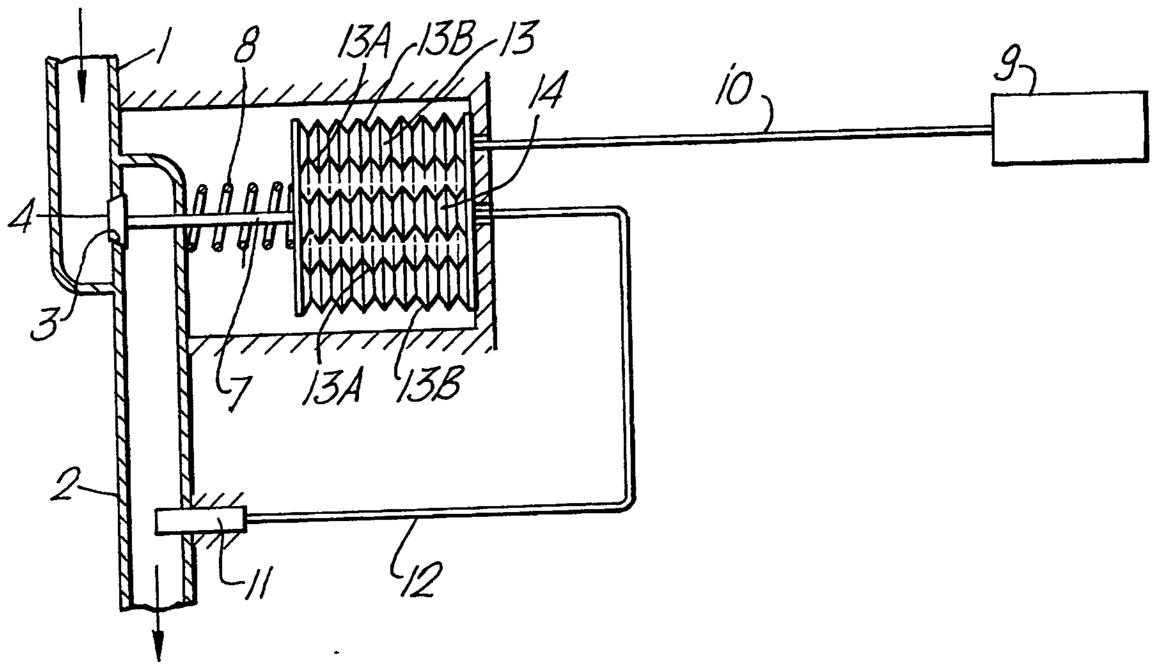
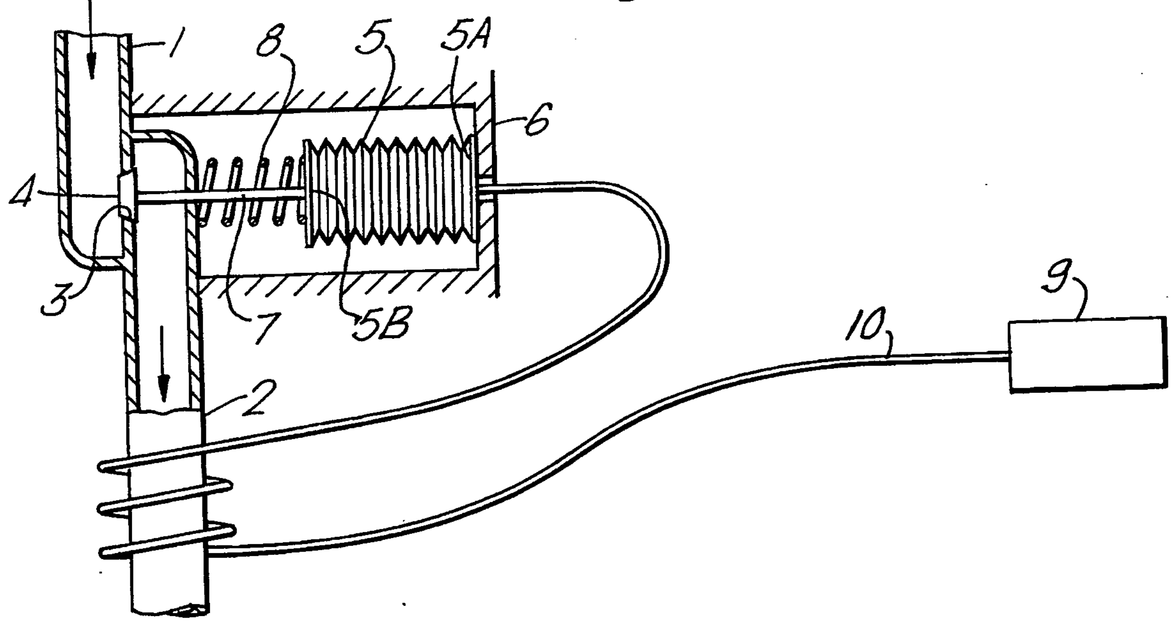


Fig. 4.



SPECIFICATION

Control valve

This invention relates to a control valve, and in particular to a control valve which responds to changes in temperature.

According to the present invention, there is provided a control valve including a valve body having an inlet and an outlet for a fluid controlled by the valve, a movable valve member mounted for movement relative to a valve seat to open and close the valve and so control flow of the fluid from the inlet to the outlet, and detecting means able to detect temperature changes at two separate locations and arranged to cooperate with the movable valve member such that temperature changes over at least part of the operating temperature range of the apparatus at both locations cause the valve member to move relative to the seat.

With this arrangement, a single valve can respond to temperature changes at two locations.

Desirably, the valve includes an actuator which causes the valve member to move relative to the seat. Conveniently the actuator comprises a bellows which expands and contracts to cause the valve member to move. Advantageously there is only one actuator, the said one actuator being influenced by temperature changes at the said two locations.

Desirably the actuator constitutes part of the detecting means. In this case, if the actuator comprises a bellows, the bellows may be located so as to sense temperature changes at one of the said two locations.

Conveniently the detecting means includes a detecting fluid arranged to change its volume in response to temperature changes, and so to detect the said temperature changes. Advantageously a single body of the detecting fluid is provided in communication with both of the said two locations to sense temperature changes at them. Desirably this is achieved by arranging the body of detecting fluid within the actuator, there to sense temperature changes at one location, in communication with another part of the detecting means at the other location.

Alternatively two parts of the detecting means at the said two locations may be separate from the actuator, but connected to it. Where the detecting means includes a body of detecting fluid, one part of the detecting means at one of the said two locations may be connected to the actuator by a conduit for the detecting fluid, part of the conduit constituting another part of the detecting means and arranged to detect temperature changes at the other of the said two locations.

Conveniently the actuator comprises two bellows operating in parallel, each connected to one of the said two locations. Advantageously the two bellows are arranged coaxially one within the other.

Desirably the arrangement is such that temperature changes at the said two locations have different effects upon the movement of the valve member. Conveniently this is achieved by an arrangement in which the transfer of heat from the said two locations takes place at different rates. Alternatively or additionally the amounts of detecting fluid in communication with the said two locations may be variable in order to achieve different effects of temperature changes at the said two locations.

Conveniently the valve is arranged to control the passage of heating fluid in a heating system. Advantageously the detecting means at one of the said two locations is arranged to detect temperature changes in the heating fluid of the heating system. Desirably the said one location is located at a heating element of the heating system downstream from the point at which the heating fluid enters the heating element. The heating element may be a radiator. Conveniently the said one location is at the exit of the heating fluid from the heating element. Advantageously the valve is at the exit of the heating fluid from the heating element and controls the heating fluid leaving the heating element.

As an alternative to the above arrangements, the valve may be arranged to control the passage of cooling fluid in a cooling system.

Desirably the detecting means at the other of the said two locations is arranged to detect temperature changes in air or other substance heated by the heating system (or cooled by the cooling system).

Conveniently the arrangement is such that control of the valve normally rests with the detecting means at the said other of the said two locations, but that under particular conditions control passes to the detecting means at the said one of the said two locations. The particular conditions having this effect may include a high return temperature of the heating fluid.

There is also provided according to the present invention a heating system including a control valve as specified in any one of the above paragraphs. Similarly, there is also provided according to the present invention a cooling system including a control valve as specified in any of the above paragraphs.

Embodiments of the invention will now be described by way of example, with reference to the accompanying drawings, in which *Figures 1, 2, 3,* and *4* are schematic sectional views of different embodiments of control valve.

Referring firstly to Figure 1, there is shown a control valve having a body including a water inlet 1, an outlet 2 and a valve seat 3, and a movable valve member 4 movement of which controls the flow of water from the inlet to the outlet. The valve is connected so as to control the flow rate of water leaving a radiator (not shown) or other heating means. Thus water from the radiator flows to the inlet 1 and from the outlet 2 back to a boiler or, if the radiator is being used for cooling rather than heating, to a chiller.

The valve member 4 is caused to move to and from the valve seat 3 by means of detecting means, the detecting means being able to detect temperature changes. Part of the detecting means is constituted by a bellows 5, the bellows 5 being filled with a vapour/liquid mixture of propane, or similar material. The bellows 5 has an end 5A, furthermost from the valve seat 3, which abuts a fixed stop 6, while its

other end 5B acts against a plunger 7 connected to the valve member 4, and against a compression spring 8 which urges the end 5B of the bellows 5 to the right, as seen in Figure 1. An additional valve spring (not shown) acts upon the valve member 4 to urge it to the right, as seen in Figure 1, into an open position, thereby keeping the plunger 7 in contact with the end 5B of the bellows 5.

Another part of the detecting means is constituted by a remote air sensor 9, which is connected to the bellows 5 by a capillary tube 10. The sensor 9 is situated in a position to sense the temperature of air heated by the radiator and comprises a sealed metal canister filled with propane. The capillary tube 10 transmits changes in pressure in the canister to the bellows 5.

The apparatus described is able to detect temperature changes at two separate locations. On the one hand the propane in the sensor 9 is affected by temperature changes in the air surrounding it. On the other hand the propane in the bellows 5 is affected by temperature changes in the water flowing through the valve, since heat from the water is conducted through the valve body to the bellows 5. An increase in temperature of the propane in the bellows 5 and/or the sensor 9 causes more of the liquid propane to convert to its vapour state and thus increases the propane vapour pressure. As a result the bellows 5 tends to expand, pushing the plunger 7 and hence the valve member 4 towards the valve seat 3 against the force of the spring 8, thereby reducing the flow rate of water through the valve. Similarly a decrease in temperature causes the valve to open. The valve is therefore responsive both to the temperature of air heated by the radiator and to the return temperature of water returning from the radiator to the boiler.

The apparatus is arranged so that temperature changes at the two locations, the sensor 9 and the bellows 5, have different effects upon the movement of the valve member 4. This is achieved because the rate at which heat is transferred from the air through the sensor 9 and capillary 10 to the bellows 5 is different from the rate at which heat is transferred from the water through the valve body to the bellows 5. The arrangement is such that, at normal operating temperatures, movement of the valve member 4 is controlled by changes in the air temperature at the sensor 9. As the air temperature increases, the valve tends to close, so reducing the flow rate of water through the radiator and the valve. At this reduced rate of flow, the water spends a longer time passing through the radiator, and this ensures that an adequate amount of heat is removed from the water during its passage through the radiator. The return temperature of the water, therefore, is satisfactorily low.

If the air temperature falls, however, the valve tends to open, increasing the flow rate of the water. Until a certain point is reached, an adequate amount of heat continues to be removed from the water during its passage through the radiator, and the return temperature of the water remains satisfactorily low. At that certain point, however, corresponding to a particularly low air temperature as sensed by the sensor 9, or caused by a change in hydraulic conditions in the circuit, the valve is open to such an extent, and/or the water flow rate has increased to such an extent, that the flow of water through the radiator is greater than that required by the hydraulic design of the system. Under these circumstances therefore, either because of a particularly low air temperature or as a result of start-up conditions, the return water temperature will rise to an undesirably high value and the balance of the system is impaired.

The arrangement of the apparatus is such that under these circumstances of undesirably high return water temperature, overriding control of the position of the valve member 4 passes from air temperature changes detected by the sensor 9 to water temperature changes detected by the bellows 5. The result is that the undesirably high return temperature of the water is transmitted through the valve body to the bellows 5 and causes the valve to tend to close. The valve member 4 moves closer to the valve seat 3, and the water flow rate is reduced. The water passes more slowly through the radiator, more heat is removed from it during its passage, and the return water temperature again becomes satisfactorily low, reducing the flow rate and restoring the balance of the system. The point at which control passes from air temperature to return water temperature is a function of the design of the apparatus and in particular of the heat transfer arrangements from the air and the return water to the bellows 5. These factors must be carefully controlled during manufacture of the valve therefore.

Once the return water temperature has fallen to a satisfactorily low level, overriding control of the position of the valve member 4 ceases to be exercised by water temperature changes detected by the bellows 5, and control passes back once again to air temperature changes detected by the sensor 9.

The valve can include means (not shown) to adjust the compression of the spring 8 to allow the temperature characteristics of the valve to be adjusted.

Many modifications to the above described arrangement are possible. Whilst the valve has been described as being charged with propane, other fluids could be used. Alternatively solid materials, for example waxes, could be used to transmit temperature changes. Any other means of detecting and/or transmitting temperature changes, for example electric means, could be used.

Another embodiment of control valve is shown in Figure 2, the valve being similar in operation to that of Figure 1 except that it is responsive to the return water temperature by means of a separate sensor rather than by heat conduction to the bellows 5 through the valve body. Accordingly, in the Figure 2 arrangement, a sealed canister 11 containing propane is arranged in the water outlet 2 to sense the return water temperature directly, the canister 11 being connected by a further capillary tube 12 to the bellows 5.

Referring now to Figure 3, there is shown a control valve generally similar in operation to the Figure 2 arrangement except that the bellows 5 has been

modified to ensure that vapour pressures established by the sensors 9 and 11 act separately on the plunger 7. The bellows 5 comprises a first generally cylindrical bellows 13 having inner and outer walls 13A and 13B within which is received a second bellows 14. The bellows 13 is connected to the air temperature sensor 9 while the bellows 14 is connected to the water temperature sensor 12.

Another example of the control valve is shown in Figure 4. In this case the capillary tube 10 between the sensor 9 and the bellows 5 is arranged in close contact with the return water outlet 2, for example by being coiled round the outlet 2, as shown. Changes in the return water temperature are therefore detected by the capillary tube 10 itself, without the need for a separate, additional sensor.

It is believed that the control valve described with reference to Figure 1 can be manufactured by suitable modification of an existing market product namely the Danfoss 13U 1255 type RAVV valve manufactured by Danfoss Corporation Limited, but with a "sensor warmer charge" as opposed to a "sensor cooler charge" as currently marketed and with a suitably modified heat transfer mechanism between the body of the valve and the temperature sensing head of the valve to render the valve responsive to return water temperature. The terms "sensor warmer" and "sensor cooler" are used by Danfoss Corporation Limited to describe the different relative amounts of liquid and vapour used in the valve and the action thereof, and are defined as follows:-

"Sensor Cooler" - In the case of the sensor cooler charge for satisfactory operation and temperature control, the sensor has to be at a lower temperature than the actuating phial in the head of the valve, actuating the valve locally.

"Sensor Warmer" - In the case of the sensor warmer charge, for control to be achieved, the temperature being sensed has to be higher than the temperature of the phial in the head of the valve, actuating the valve.

The embodiments of the invention described above by way of example have all related to valves used in a central heating system to control the return water flow from a radiator. However the control valve could also be used in systems other than central heating systems, and could be used to control the flow of fluids other than water. In any such alternative arrangement the apparatus shown in the drawings would have the useful property of being able to sense temperature changes at two separate locations, and to exert control over a single valve based on the temperature changes it sensed.

In principle therefore the control valve could be arranged to respond to temperature changes at any two locations. When the embodiments shown in the drawings are used to control water in a central heating system however, a particularly useful effect is achieved, as described above, by sensing the return water temperature. In order to achieve this useful effect, it is not essential to sense the temperature of water as it leaves the radiator. The water temperature could be sensed at any desired point after it has started to give up some of its heat, that is to say after it has entered the radiator. Even if the water temperature was sensed at a location very soon after it had entered the radiator, the temperature at that location would give an indication of the amount of heat to be given up by the water in its passage through all of the radiator, and hence of the temperature of the water returning to the boiler.

The apparatus described above and shown in the drawings has a feature whereby, under certain circumstances such as start-up conditions or very low temperature of the air at the sensor 9, control of the valve passes from being dependent on the air temperature to being dependent on the return water temperature. The point at which control passes from one to the other is, as described above, a function of the design of the valve including in particular the heat transfer arrangements from the air and the return water to the bellows 5. As an alternative and/or additional means of controlling the point at which control passes from one to the other, it would be possible to adjust the volume of liquid propane present in the sensor 11 (if present, see Figures 2 and 3) and/or the sensor 9 and/or the bellows 5.

Means may be provided, not shown in the drawings, to vary the volume of the bellows 5, and/or the sensor 9, and/or the sensor 11. In the case of the bellows 5, this would be achieved by an arrangement whereby the stop 6 abutting the end 5A of the bellows 5 was variable in position to shift the end 5A to the left or right as seen in Figure 1 and so to vary the volume of the bellows 5. This would in turn vary the pressure of the propane in the bellows 5, and so affect the relationship between temperature changes and movement of the valve member 4, thus allowing the characteristics of the valve to be adjusted at will.

In the case of the sensors 9 and 11, similar means could be provided to alter the volume of the sensor 9 or the sensor 11, to alter the relationship between movement of the valve member 4 and temperature changes sensed by the sensor 9 or the sensor 11.

CLAIMS

1. A control valve including a valve body having an inlet and an outlet for a fluid controlled by the valve, and a movable valve member mounted for movement relative to a valve seat to open and close the valve and so control flow of the fluid from the inlet to the outlet, and detecting means able to detect temperature changes at two separate locations and arranged to cooperate with the movable valve member such that temperature changes over at least part of the operating temperature range of the apparatus at both locations cause the valve member to move relative to the seat.

2. A control valve as claimed in Claim 1, in which the control valve includes an actuator which is arranged to cause the valve member to move relative to the seat.

3. A control valve as claimed in Claim 2, in which the actuator is arranged to expand and contract to cause the valve member to move.

4. A control valve as claimed in Claim 3, in which the actuator comprises a bellows.

5. A control valve as claimed in Claim 2, Claim 3

or Claim 4, in which the control valve includes only one actuator, the actuator being arranged to be influenced by temperature changes at both of the said two locations.

6. A control valve as claimed in any one of Claims 2-5, in which the actuator constitutes part of the detecting means.

7. A control valve as claimed in Claim 6, in which the actuator is located so as to sense temperature changes at one of the said two locations.

8. A control valve as claimed in any preceding claim, in which the detecting means includes a detecting fluid arranged to change its volume in response to temperature changes and so to detect the said temperature changes.

9. A control valve as claimed in Claim 8, in which a single body of the detecting fluid is provided in communication with both of the said two locations to sense temperature changes at them.

10. A control valve as claimed in Claim 9, in which the body of detecting fluid is arranged within the actuator, there to sense temperature changes at one location, and in communication with another part of the detecting means at the other location.

11. A control valve as claimed in any one of Claims 2 to 10, except Claim 6 or any of Claims 8 to 10 when dependent directly or indirectly on Claim 6, in which the two parts of the detecting means at the said two locations are separate from, but connected to, the actuator.

12. A control valve as claimed in Claim 1 when dependent on any one of Claims 8 to 10, in which one part of the detecting means at one of the said two locations is connected to the actuator by a conduit for the detecting fluid, part of the conduit constituting another part of the detecting means and being arranged to detect temperature changes at the other of the said two locations.

13. A control valve as claimed in Claim 2 or any of Claims 3 to 12 when dependent directly or indirectly on Claim 2, in which the actuator comprises two bellows operating in parallel, each connected to one of the said two locations.

14. A control valve as claimed in Claim 13, in which the two bellows are arranged coaxially one within the other.

15. A control valve as claimed in any preceding claim in which the arrangement is such that temperature changes at the said two locations have different effects upon the movement of the valve member.

16. A control valve as claimed in Claim 15 in which the arrangement is such that transfer of heat from the said two locations through the detecting means takes place at different rates.

17. A control valve as claimed in Claim 15 or 16 when dependent directly or indirectly on Claim 8, in which the amounts of detecting fluid in communication with the said two locations are variable in order to achieve different effects of temperature changes at the said two locations.

18. A control valve as claimed in any preceding claim, in which the valve is arranged to control the passage of heating fluid in a heating system.

19. A control valve as claimed in any of Claims 1 to 17 in which the valve is arranged to control the passage of cooling fluid in a cooling system.

20. A control valve as claimed in Claim 18 or 19 in which the detecting means at one of the said two locations is arranged to detect temperature changes in the heating or cooling fluid of the system.

21. A control valve as claimed in Claim 20 in which the said one of the said two locations is located at a heating or cooling element of the system but downstream from the point at which the heating or cooling fluid enters the element.

22. A control valve as claimed in Claim 21 in which the said one location is at the exit of the heating or cooling fluid from the element.

23. A control valve as claimed in Claim 21 or 22 in which the valve is at the exit of the heating or cooling fluid from the element and controls the heating or cooling fluid leaving the element.

24. A control valve as claimed in any one of Claims 21 to 23 in which the element is a radiator.

25. A control valve as claimed in any one of Claims 21 to 24 in which the detecting means at the other of the said two locations is arranged to detect temperature changes in the air or other substance heated or cooled by the system.

26. A control valve as claimed in Claim 25 in which the arrangement is such that control of the valve member normally rests with the detecting means at the said other of the said two locations but that under particular conditions control of the valve member passes to the detecting means at the said one of the said two locations.

27. A control valve as claimed in Claim 26 in which the arrangement is such that the said particular conditions include a high return temperature of the heating fluid.

28. A heating system including a control valve as claimed in any preceding claim.

29. A cooling system including a control valve as claimed in any one of claims 1 to 27.

30. A control valve as claimed in Claim 8 or any of Claims 9 to 29, when dependent directly or indirectly on Claim 8, in which the detecting fluid is contained within a chamber whose volume is adjustable.

31. A control valve as claimed in Claim 30, in which the adjustable volume chamber constitutes the actuator.

32. A control valve as claimed in Claim 30 or 31, in which the adjustable volume chamber is located at one of the said two separate locations.

33. A control valve as claimed in Claim 30 or 31 or 32, in which adjustable volume chambers are located at both of the said two separate locations.

34. A control valve substantially as herein described with reference to and as shown in Figure 1, Figure 2, Figure 3 or Figure 4 of the accompanying drawings.

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